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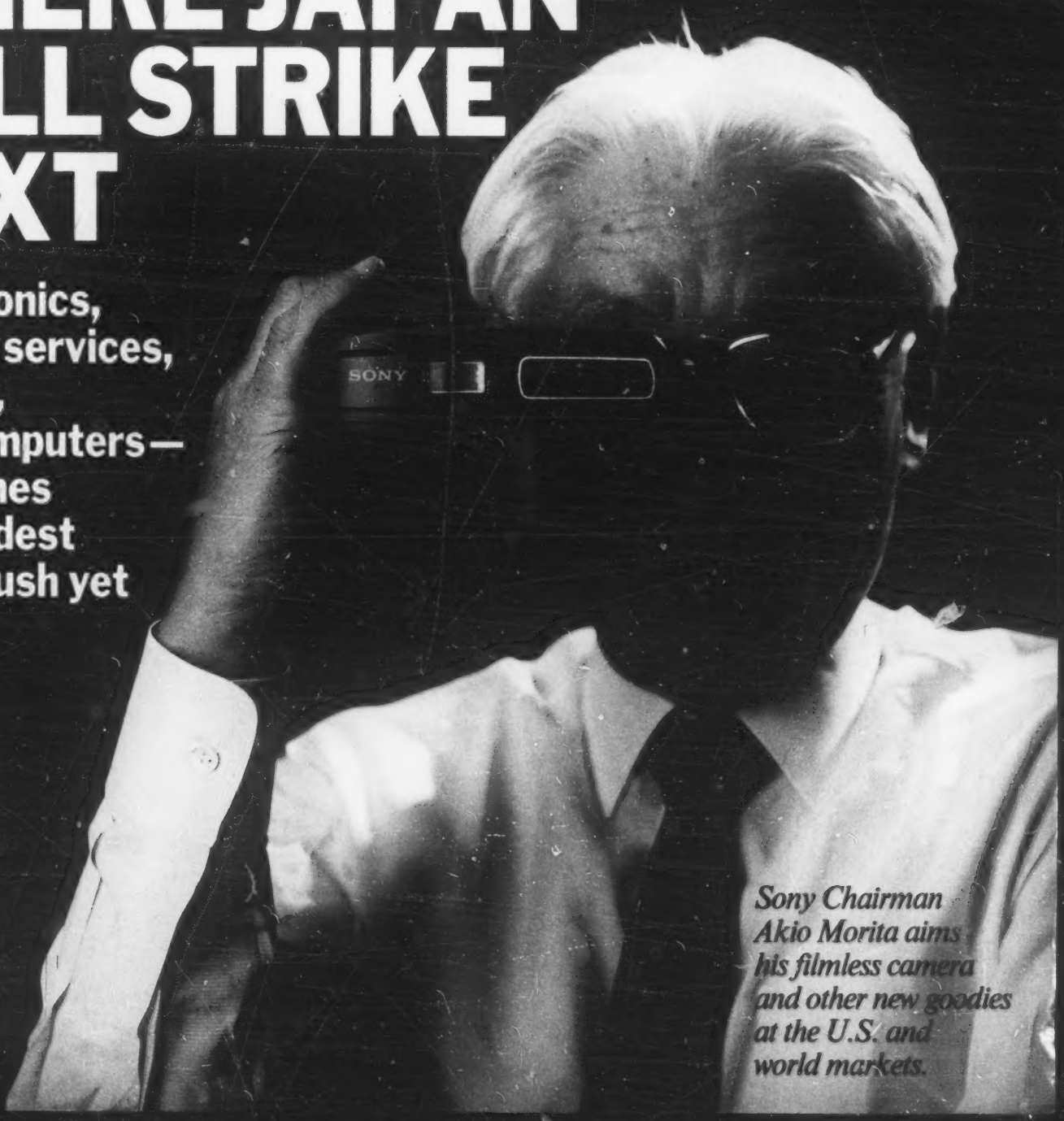
FORTUNE

WHERE JAPAN WILL STRIKE NEXT

In electronics, financial services, retailing, supercomputers—here comes the broadest export push yet



Sony Chairman Akio Morita aims his filmless camera and other new goodies at the U.S. and world markets.

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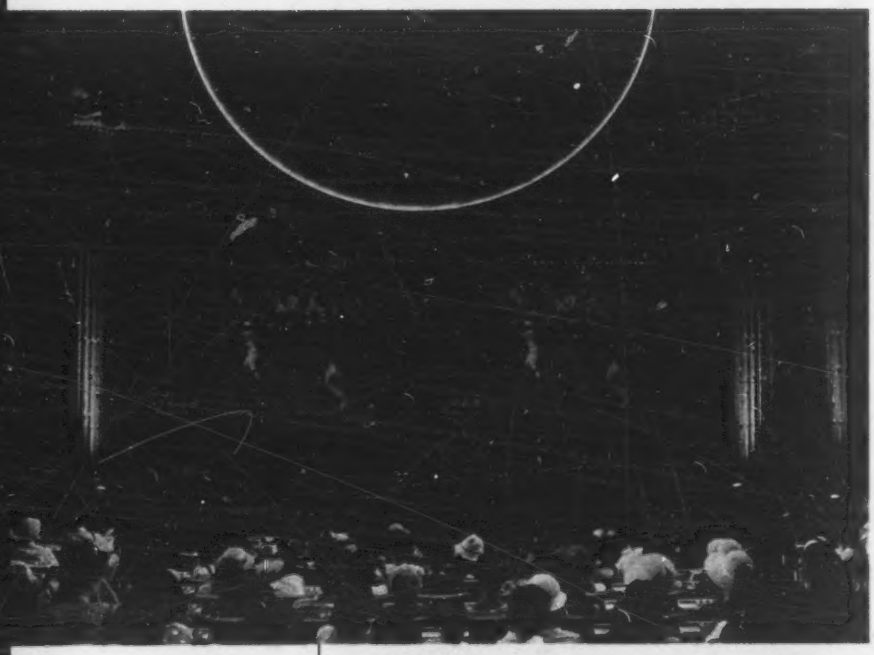

ABOVE: A demonstration of Hitachi's high-definition TV screens, photographed in Yokohama by Robert Wallis—Sipa

COVER: Sony's Akio Morita holding a Mavica MVC-C1 electronic still camera, photographed by Caroline Parsons

They are confident—even arrogant—about their ability to innovate in technology. PAGE 42

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Loaded with cash and eager to head off fire-breathing challenges from Korea and other growing Asian dragons, the folks who brought you the Walkman, the VCR, and the Honda are readying a sunburst of new products and services. Among them: tape recorders the size of a matchbox and flat TV screens that you can hang on walls. The Japanese will go after new business where they have only beachheads or no presence at all—even hamburgers in Honolulu. Rivals beware. *by Gene Bylinsky*

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"America no longer makes things, it only takes pleasure in making profits from moving money around."

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"They rank the Harley look right up there with motherhood and God."

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"Transforming a corporate culture is a far more complex dynamic than can be controlled by single individuals."

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Mainline churches are losing members, but smart pastors know how to call home the wandering lambs. Words familiar in boardrooms—market research, customer satisfaction—resound in pastoral offices. A look at success in the religious world reveals a great deal about managing in the secular. *by Thomas A. Stewart*

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Want to win a lawsuit? Just call an all-purpose expert. For a fee, you can find one to "prove" almost anything. Swearing that a product was misdesigned, self-styled accidentologists often make a big hit with juries. But judges are starting to rebel. *by Walter Olson*

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Turning the workers into owners has long seemed like a terrific idea, and companies threatened by takeover have lately seized on ESOPs as a raider repellent. But the outside shareholders, the company, and the employees themselves can suffer in the long term. *by Sylvia Nasar*

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EDITOR'S DESK

JOHN S. ABBOTT

Executive editor Armstrong: grace, style, and wisdom

SOME PEOPLE are consummate journalists. One such rare talent is Richard Armstrong, who as our executive editor since 1977 has been a chief architect of FORTUNE. I say has been, unfortunately, because he is retiring after 20 years of lending his grace, style, and wisdom to our magazine.

For most of his time here, Dick has been an editor. His genius at this has never been questioned, only how he does it. The editor's job is not easily visible to the reader. The stories you read are expressions of our writers, but the big-picture polish or the tiny phrase that clarifies a thought are often provided by our editors. As Dick himself once put it, "I sit in for the reader, and I assume he or she is as bright as I am. If I can't follow a line of reasoning, I question it."

Few of us have his gift for "cellophane editing," his ability to repair a busted passage so subtly as to mimic the transparency of Scotch tape. His habit of preserving the voice of the author has made him the favorite editor of an entire generation of FORTUNE writers, many now editors themselves. My predecessor, Bill Rukeyser, explains, "He mastered the hardest thing for an editor to master—to edit just enough."

A Mississippian, Dick came to us by way of the University of Missouri School of Journalism, the Gadsden *Times* in Alabama, the U.S. Army (first lieutenant, artillery, Korean war), Columbia University (M.A., English lit), *Time*, and the *Saturday Evening Post*. After a short tour as a FORTUNE writer—he wrote precisely two stories—he was promoted to become an editor.

Fellow executive editor Allan Demaree calls him "the best pencil editor ever," which paints a literal picture of Dick at work. His office is always neat, the desk immaculate, excess paper disposed of. Manuscripts are neatly squared next to sharpened No. 2 pencils. Dick can be seen sitting before a manuscript, hands folded, deep in concentration. When he returns to the article at hand, he adds a few deft strokes, and it is done. Writers were grateful that he took time just to think. Says one: "He has always been inspiring to me. He never seemed harried, but he was always intellectually engaged."

So what is next for a journalist whose pen has recorded some four decades of change? A trip with his wife, Nancy, a former *Time* picture researcher, to visit their daughter Lucy, a novelist in Oxford, England. More time to go to the opera and listen to the classical music he loves. And reading, even more than the prodigious amounts he does now (he has finished *War and Peace* three times). "Reading is the best training for writers that there is," he says. Happily, he will return as a contributing writer, following a grand tradition of many of FORTUNE's editors past. The pleasure of such company will be yours as well as ours.

Marshall Loeb
MANAGING EDITOR

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REACH FOR THE STARS

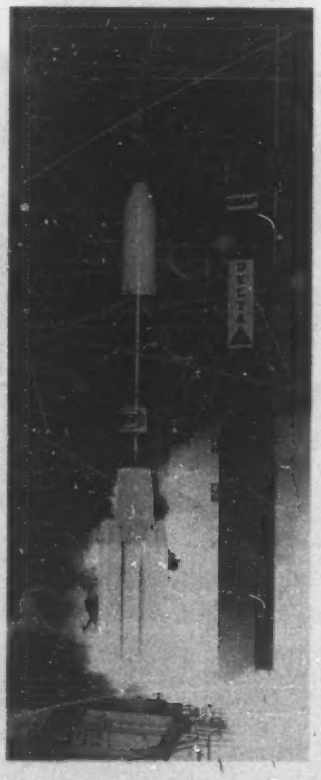
■ As *Voyager II* ended its stunningly successful 12-year grand tour of the outer planets with its flyby of Neptune and its moon Triton (shown above), funding for America's civilian space program seems headed, like the probe, into a void. Measured in constant dollars, NASA's budget appropriation, $10.9 billion in 1989, is less than half what it was in 1966. In July, President Bush called for a renewed national commitment to civilian space exploration. But the Administration's 1990 budget asks that Congress lift NASA spending a modest $2 billion, about $1 billion more than the House Appropriations Committee is ready to authorize.

The U.S. can, and should, spend more on space. A reasonable goal would be to boost NASA funding to $15 billion next year. Few, if any, other federal programs yield such astronomical dividends. In a recent study, the Midwest Research Institute, a nonprofit think tank based in Kansas City, Missouri, calculated that each R&D dollar spent by NASA generates $9 in private spending.

Those dollars would likely go further were NASA to tip its spending more toward cost-effective unmanned space probes instead of continuing to pour disproportionately large sums into manned space shuttle missions. NASA officials and the major contractors that profit from its $24 billion shuttle program defend manned space flight on the ground that it galvanizes public support for space exploration. But *Voyager* did more to advance human knowledge about the heavens and to fire public excitement—all for a comparatively trifling $865 million. Similar giant leaps for science and popular enthusiasm are likely to result from successful launchings next year of the Hubble space telescope, which will search for the edge of the universe, and the upcoming Galileo mission to Jupiter.

Smart spending on many more unmanned space probes will also advance the private commercialization of space. In August **McDonnell Douglas** successfully sent up a communications satellite, America's first commercial launch (shown at left) of an orbiting payload. The company has launch orders worth $400 million booked through 1991. **General Dynamics** and **Martin Marietta** are also vying with state-funded European, Japanese, Soviet, and Chinese space programs for commercial launching contracts. The combination of an expanded NASA commitment to unmanned scientific exploration of space and a viable commercial space industry is America's best bet to reach a galaxy of useful technological breakthroughs. **– Rahul Jacob**

Soaring aloft on private wings



NASA'S TOP CONTRACTORS

COMPANIES & PROJECTS	1988 in millions
Rockwell International Shuttle main engines	$1,714
Lockheed Test site support and engineering	$811
Morton Thiokol Shuttle solid rocket boosters	$423
Martin Marietta Shuttle external fuel tanks	$341
Boeing Space station life support	$302
McDonnell Douglas Space station propulsion	$299
General Electric Communications satellites	$218

BEATING THE BUSY SIGNAL

■ It's a familiar and frustrating scenario: You're at an airport pay phone, dialing furiously, and hear the final boarding call for your flight. Then you get a busy signal on that important call. Aaargh! Relief is on the way, though. Soon you'll be able to record a 20-second message and let the phone redial the number every 15 minutes for two hours until someone answers—at no extra charge.

Smart phones with this new feature are already in use in hotels and businesses around Dallas, where **Intellicall**, their manufacturer, has its headquarters. They can also make collect calls with a recorded operator's voice placing the call in English or Spanish, saving the caller extra charges by avoiding a human operator.

Intellicall, headed by Chairman A. Michael Adler and CEO R. Stephen Polley, holds 60% of the fast-growing niche for privately owned pay phones. The regional Bell companies can only operate pay phones; they are prohibited from manufacturing and selling them. Sales of Intellicall's smart phones, which cost $1,200 and are bought by businesses that get a slice of the revenues they generate, are filling the company's coin box.

PHIL HUBER—BLACK STAR

Intellicall's Adler and Polley

For the first half of 1989, sales have almost matched the $37.9 million for all of 1988.

– Wilten Woods

THE MUPPETS SELL OUT

■ Miss Piggy might snort at the thought of sharing center stage with Minnie Mouse. But she'll have to get used to it because the piggadonna, Kermit the Frog, and scads of other

BY FAYE RICE

CEOs THINK THE SEVEN-YEAR BOOM HAS AT LEAST ANOTHER YEAR TO RUN

■ It was a soft landing, all right. Did anyone even feel it? The revised figures the Commerce Department released in late August for second-quarter GNP growth showed an economy that buzzed the control tower before climbing at a 2.7% rate. No recession this year, folks, and America's top executives are convinced there won't be one next year either. They are right in line with FORTUNE, which believes that a recession is unlikely because the trade deficit is narrowing, consumers and businesses are continuing to spend—albeit cautiously—and employment will stay high.

The executive mood is important because it bodes well for capital spending and other business outlays. As a group the CEOs are upbeat not just about the economy but also about the financial markets: They expect the prime rate to fall slightly by the end of 1989 and stock prices to remain robust throughout 1990. Which is not to say they don't have a few gripes. They are thoroughly fed up with the budget deficit and the profligate Congress. Robert H. Brethen of Philips Industries grumbles, "We need more concrete plans, not conversation." Sara Lee's John H. Bryan echoes the sentiment somewhat more passionately: "It is heresy to say we don't like economic expansion, but it's time for the federal government to set an example for savings."

These are among the results of the latest FORTUNE 500/CNN Moneyline CEO poll. The independent opinion research firm Clark Martire & Bartolomeo conducted the survey of 204 chief executives between August 16 and August 24, the day the Dow Jones industrial average vaulted 12 points above its pre-crash record of 2722, set almost exactly two years earlier.

The survey found that 59% of the chief executives do not expect a recession to grip the country by the end of 1990. The seven-year economic boom has already survived many predictions of its demise, and these leaders expect it to keep rolling for at least another year. Most would agree with David Kearns of Xerox, who says: "Inflation is under control and we're basically doing okay now. We can probably get through 1990 without any disasters."

"We can probably get through 1990 without any disasters."

DAVID KEARNS
Xerox

What federal policy moves would be most helpful in extending the current economic expansion? You won't be amazed to hear that 47% of the CEOs want a smaller budget deficit. They have made their dissatisfaction known in previous FORTUNE polls, but now their patience is wearing thin. Without prompting they offer their own prescriptions for shrinkage. Says C. J. Silas of Phillips Petroleum: "Congress cannot balance the budget with mirrors. It must be willing to close extra military bases and reduce weaponry."

Many of Silas's peers concur. "I'm all for the military but not military waste," says Ted C. Wetterau of Wetterau Inc. "We must zero in on businessmen who manufacture the government tanks and ships, and make them learn to be cost-efficient." David Johnson of Gerber Products believes the government will have to improve its own productivity to make a dent in the deficit: "Congress and the President must beat the table and set up better criteria for efficiency. HUD is an example where controls are needed."

When they were polled last December, an overwhelming 68% of chief executives recommended tax increases as well as spending cuts to narrow the middle-aged spread between income and outgo. Somewhat surprisingly, a mere 7% are tax hawks now, but they are resolute. Says Harry Stonecipher of Sundstrand Corp: "The President must have the courage to increase taxes. Otherwise, he will reinherit the wimp image."

Some 36% think the Fed should reduce interest rates to keep the economy chugging along. Says Warren Batts of Premark International: "We should refrain from

Q Do you expect a recession to begin by the end of 1990?

A

Yes	38%
No	59%
Not Sure	3%

Q Where do you expect the Dow Jones industrial average to stand on December 31, 1990?

A

1500–2000	6%
2000–2500	44%
2500–3000	42%
Over 3000	5%
Not Sure	3%

Q Which do you consider the greater threat in the next two years, recession or inflation?

A

Recession	60%
Inflation	39%
Not Sure	1%

"Industry is stronger than we thought a few months ago."

TOM H. BARRETT
Goodyear

BILL BAUERMEISTER

tampering too much with the money supply, but we must lower interest rates to stimulate growth and then follow Greenspan's excellent guidelines." Indeed, Chairman Alan Greenspan and his staff at the Federal Reserve earn considerable praise for their deft management.

The optimism is far from universal. Fewer CEOs are bullish now than at the beginning of the year. Last December only 16% believed we would head into a recession during 1989. Now, 38% are fretting about bad times in 1990. Says Rand Araskog of ITT: "I just think all of this debt—federal, junk, and corporate—will catch up with us." He notes that corporate debt has increased some $900 billion during the past five years, while equity has declined $465 billion: "The debt-to-equity ratio has weakened considerably."

He is joined by Robert B. O'Brien Jr. of New Jersey–based Carteret Savings Bank, who believes that the weakness of small business is recession's leading indicator. "The small businessman relies more on bank credit, and he is paying more for it now than he should. He can't pass it along to his customers because his foreign competitors don't have to." But none of the top executives who are predicting a recession for the coming year believe it will be severe. The response of H. Howard Stephenson of Bancorp Hawaii is typical: "I don't think it will be a disaster. It could just be more of a readjustment."

"I'm all for the military but not military waste."

TED C. WETTERAU
Wetterau

For all their short-term optimism, 60% of CEOs think recession is a greater threat to the economy than inflation in the next two years. Here they part company with FORTUNE, which reckons that prices will climb an average 5.5% or worse next year, forcing Greenspan to screw down credit to try to tame inflation without tipping over into recession.

The corporate chiefs anticipate that interest rates will ease before the end of 1989. Nearly two-thirds expect the prime rate will drop from its present 10.5% to a range of 9% to 10%, and some forecast rates below 9%. James Will of Cyclops Industries speaks for the majority: "I think the economy will get more bogged down than some expect, and the Fed will have to do something to crank it back up." He thinks the prime rate will trickle down to about 9.5% by year-end.

A sizable CEO contingent, 28%, is less hopeful. They say the prime rate will remain in the 10% range. "The Fed is still concerned about inflation, and I don't think rates will be lowered until it is statistically satisfied that easing up will be the right approach," says Joseph Pinola of First Interstate Bancorp, headquartered in Los Angeles.

Despite their growing worries about recession, the CEOs are actually more confident than they were two years ago that the stock market will remain strong. Just after the October 1987 crash, more than half the chief executives believed the Dow would be in the 2000 to 2500 range by the end of 1988, and 39% thought it would be lower. Now, 44% of the leaders still expect the Dow to be in the 2000 to 2500 range a year from now, though most speculate that it will be closer to 2500. Says James Dresher of York International, an air conditioner manufacturer: "The market is just a little ahead of itself now. The economy has been on such a sustained period of growth, the market seems to think there is no end to it, and that is not the real world."

"The options for risk taking and reward are scarcer than ever."

DAVID JOHNSON
Gerber

LEE BAUERMAN

An impressive 47% are more sanguine. They see the Dow above 2500 a year from now. Says Johnson of Gerber, whose number is 2800: "It is the only game in town. There are no more tax havens, so the options for risk taking and reward are scarcer than ever." Tom H. Barrett of Goodyear also thinks the Dow will leap above the present 2700. His reason is that "the economy is not going to collapse on us, and industry is stronger than we thought a few months ago." ■

Q A

What do you expect the prime rate to be at year-end 1989?

Less than 9%	8%
9%–10%	60%
10%	28%
11%	2%
Not Sure	2%

Q A

What policy move or moves—by the President, the Congress, or the Fed—would be most helpful in extending the current economic expansion?

Reduce budget deficit	47%
Reduce interest rates	36%
Do nothing	17%
Moderate expansion of money supply	14%
Reduce capital gains and other taxes	9%
Reduce trade deficit	8%
Increase saving	7%
Increase taxes	7%
Other	16%

Totals more than 100% due to multiple responses.

THE METHANOL CAR IN YOUR FUTURE

With President Bush urging them on, the automakers are hard at work on a vehicle that will run cleaner—and accelerate faster—than one fueled with gasoline. ■ *by Andrew Kupfer*

MOVE OVER, gasoline. Autos powered by clean-burning alternative fuels are the best means to reduce lung-burning ozone in the many cities where it remains stubbornly above the federal limit. Motorists won't rebel at the change, but quite the opposite: "The new fuels will take the market by storm." Cars will pollute less *and* perform with more pizazz.

Is this Ralph Nader speaking? No, it's your self-proclaimed environmentalist President, George Bush. The most daring part of the clean air plan that he submitted to Congress directs automakers to start selling cars that will run on gasoline substitutes—500,000 units in 1995, rising to one million a year in 1997 and thereafter.

Bush's former sidekicks in the oil patch, who would have to invest billions in new plants to produce alternative fuels, are irate. Oilmen hope to run the new fuels bandwagon into a ditch by devising a cleaner-burning gasoline that could be produced in existing refineries. Under heavy lobbying, the Administration added reformulated gasoline to its list of potential alternative fuels just before releasing details of its clean air bill.

The automakers, which aim to prosper no matter what fuel the government dictates, have been working to solve problems posed by alternative fuels, notably methanol made from natural gas. Anticipating Bush's proposal, Detroit for some time has been developing flexible-fuel cars that can run on gasoline or methanol or blends of the two. Cost: $300 or so added to the car's price.

Methanol, or methyl alcohol, is the most promising substitute. Indianapolis 500 racers have used it for decades. It's safer: When cars collide, they are far less likely to explode than when using gasoline. It's more powerful and cleaner. Thanks to the fuel's superior combustion and high octane rating, an engine running on it produces up to 20% more horsepower—and up to 90% less ozone. Tailpipe emissions of volatile hydrocarbons, which combine with nitrogen oxides in sunlight to produce ozone, are far lower than with gasoline. Methanol also is much less prone to evaporate and thus produces less smog from fuel escaping to the atmosphere during refueling and when the engine is hot.

So what's the catch? Well, the stuff has a tendency to eat through metal and turn engine oil to mayonnaise. Though cars become more virile on methanol, they gulp lots of it: Because of its molecular structure, the fuel has only 60% as much energy per gallon as gasoline. Anyone worried about dwindling fossil fuels can relax: A given amount of those resources can be turned into enough methanol to do roughly the same amount of work as gasoline, even though the methanol takes up more room. But for motorists, methanol will mean more trips to the filling station.

Washington's ozone fighters are looking at a whole smorgasbord of clean fuels. The most pristine energy, from the user's standpoint, is electricity. As anyone familiar with battery-driven golf carts knows, vehicle emissions are zero. But generating the juice in a coal-fueled plant to charge the batteries can produce plenty of pollution—plus carbon dioxide, which causes global warming. When that's figured in, electric cars are not so pure (see table). A battery that delivers as much energy as just one gallon of gasoline would weigh several hundred pounds. Electric vehicles today have a range of less than 100 miles and take hours to recharge. They wouldn't be much fun to drive either, requiring an eternity by car buff standards—nearly 20 seconds—to accelerate from zero to 50 mph.

continued

Methanol, made at a Hoechst Celanese plant, looks like water.

TIM NOLAN

REPORTER ASSOCIATE *Karen Nickel*

Ethanol—which can be thought of as 200-proof vodka—is an efficient, low-polluting fuel. It is less corrosive than methanol, and it packs one-third more energy per gallon. But ethanol, which can be made only by fermenting corn or other crops rich in starch or sugar, costs twice as much per mile as gasoline. And it would take the entire U.S. corn crop to make enough fuel for a quarter of America's cars. Heavily subsidized since energy-crisis days, ethanol is used regionally in small amounts to boost octane in a gasoline blend called gasohol. Corn Belt lobbyists are working through Congress to broaden the subsidy to cover a new smog-fighting gasoline additive derived from ethanol.

TOBEY SANFORD

Another clean fuel: putting natural gas into UPS trucks

A FUEL that deserves a future, especially for urban buses and delivery vans, is compressed natural gas. Carried under pressure in thick-walled cylinders, the stuff already powers hundreds of thousands of vehicles in Italy, the Netherlands, New Zealand, and Canada. It burns cleanly, starts easily, and has an extremely high octane rating (130, vs. about 105 for methanol and the low 90s for premium gasoline). Maintenance expenses would be lower than with gasoline because natural gas is kind to engine oil.

Natural gas is ideal for vehicles that return to a home base every day. Large-fleet owners could save enough on maintenance and fuel costs to pay for converting their vehicles and buying a refueling compressor. Price: $250,000 for one that can refill gas cylinders in a few minutes. United Parcel Service is testing ten trucks altered by Brooklyn Union Gas to make deliveries in the Canarsie section of Brooklyn.

A nasty little PR problem haunts natural gas: fear of explosions. UPS picked Canarsie partly because its trucks wouldn't have to go through New York City's tunnels, where compressed gases are prohibited. But Brooklyn Union has conducted safety tests, including one in which a Mercury Marquis was dropped from 90 feet without damaging the canister. In another a stick of dynamite was taped to the tank and set off, the equivalent of a car hitting a brick wall at 89 mph. Gas leaked out but did not ignite.

The real drawback for drivers is that natural gas is inconvenient. Storing enough of it on board to travel more than 100 miles at a shot is a problem, even when the gas is squeezed to 200 times atmospheric pressure. It might be years before all filling stations offered the fuel. To keep the option of using gasoline where no gas is available, the car would need separate systems for carrying the two fuels and conveying them to the engine. Along with a gasoline tank, it would also need heavy natural gas cylinders sitting like little zeppelins in the trunk.

Modifying an existing auto to run on natural gas as well as gasoline would cost about $2,000, but far less if cars were mass-produced with dual-fuel capability or designed from scratch for natural gas alone. Since most urban homes are served by natural gas, motorists could install fueling compressors right in their garages. But it might cost $2,000 for one that would take three or four hours to fill 'er up.

SO THE BEST substitute fuel is methanol, also known as wood alcohol—the kind that's bad to drink. A liquid fuel requiring no pressurization, it could be dispensed from pumps alongside those selling gasoline. C. Boyden Gray, the President's counsel, sold his boss on clean fuels when the presidential campaign was getting under way. For five years he has driven a Chevy Citation that runs on alcohol. Tanking up with alternative fuels, Gray says, is a far less expensive way to clean the air than cracking down on small ozone-creating operations like dry cleaners and paint shops. Battling air pollution from any source is an obsession for the lanky, professorial Tar Heel. He picks up a plastic jar with a half-inch or so of nasty black grit on the bottom. "Here, see this," he says. "This is five minutes from a diesel bus. Five minutes!"

Chemical companies make 1.5 billion gallons of methanol a year in the U.S. by combining methane—the main component of natural gas—with steam at very high temperature and pressure. That output, the energy equivalent of three days' U.S. gasoline consumption, is used almost entirely by

GASOLINE VS. ALTERNATIVE FUELS

FUEL	VEHICLE EMISSIONS grams per mile				FUEL COST TO TRAVEL 100 MILES	MAXIMUM TRIP ON FULL TANK OR CHARGE	OCTANE RATING
	Hydrocarbons	Nitrogen oxides	Carbon monoxide	Carbon dioxide			
Gasoline*	1.4	.8	7.2	350	$4.00	400 miles	87–93
Methanol	.15–.25	.8	3–7	320	$3.50–$4.25	260 miles	105
Ethanol**	.5–.8	.8	6–8	140–350	$7.50–$9.00	300 miles	99
Natural gas	.15–.25	.8	1–4	300	$3.00–$5.00	100 miles	130
Electricity	.3	1.2	.05	200–300	$2.40–$4.70	60–100 miles	N.A.

*Under rules proposed in President Bush's clean air plan. **Based on a blend of 85% ethanol and 15% gasoline.

Even under proposed new rules, gasoline cars will emit far more hydrocarbons—a precursor of ozone—than those powered with other fuels. Pollution data, from the U.S. Environmental Protection Agency and based on a future 3,000-pound car that has gone 50,000 miles, include evaporation losses.

the chemical industry to make such items as the glue holding plywood together. But methanol could also shave as much as a second off the time it takes production-line cars to go from zero to 60 mph. That is possible, says Roberta Nichols, Ford's principal research engineer for fuel systems, because the fuel burns faster and at a lower temperature than gasoline.

MICHAEL L. ABRAMSON

The EPA measures emissions from a methanol car at its laboratory in Ann Arbor, Michigan.

AT THE HEART of the auto industry's plans for methanol is the flexible-fuel vehicle, or FFV. A sensor in the fuel line measures the proportion of methanol and gasoline in the mixture. Its findings are transmitted to a computer chip similar to those on most new cars, which continuously adjust the air-fuel ratio and timing for different driving conditions. If more methanol is coming through the fuel line, the computer lowers the air-fuel ratio and advances the spark to ignite the fuel sooner. Result: more oomph.

FFVs will be costlier because methanol would rot the guts of standard cars. It eats through aluminum, used in gasoline tank linings, and dissolves the rubber in fuel hoses. So automakers will outfit FFVs with stainless-steel tanks; hoses may be made of Teflon wrapped in stainless-steel mesh. Thus the added price of $300 or so. General Motors and Ford are planning to send large fleets of FFVs to California—2,200 and 2,500, respectively—by 1992 to see how they bear up under regular use, especially the fuel sensor. Chrysler, late getting into the game, will be sending out a fleet of ten.

How will Detroit market these cars? All three automakers will emphasize the chance for drivers to do their bit for the planet as well as the cars' potent engines. The performance gains will vary by make.

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"OH BOY!"

"DAD'S NOSE..."

"8 POUNDS, 3 OUNCES..."

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Because of methanol's high octane, the engine can be souped up by maximizing the compression ratio—the degree to which the fuel is squeezed before it is ignited—without causing it to knock. Since this change worsens performance when the car is running on gasoline, GM and Ford will leave the compression ratio unchanged. When fueled with methanol, the cars will still get a power boost of up to 7%. Chrysler, playing catch-up, will build FFVs with higher compression ratios, aiming for a 20% jump in power and a ride you can feel in the seat of your pants.

The flexible-fuel approach makes sense because it allows methanol-using vehicles to proliferate before the fuel is available everywhere. The President's bill calls for alternative-fuel vehicles to be sold first in the country's nine most polluted metropolitan regions.* Owners of FFVs will be expected to burn methanol exclusively when driving within these areas. Some states, such as California, may require service stations to sell clean fuels. Outside the designated areas, FFV owners will be able to use gasoline.

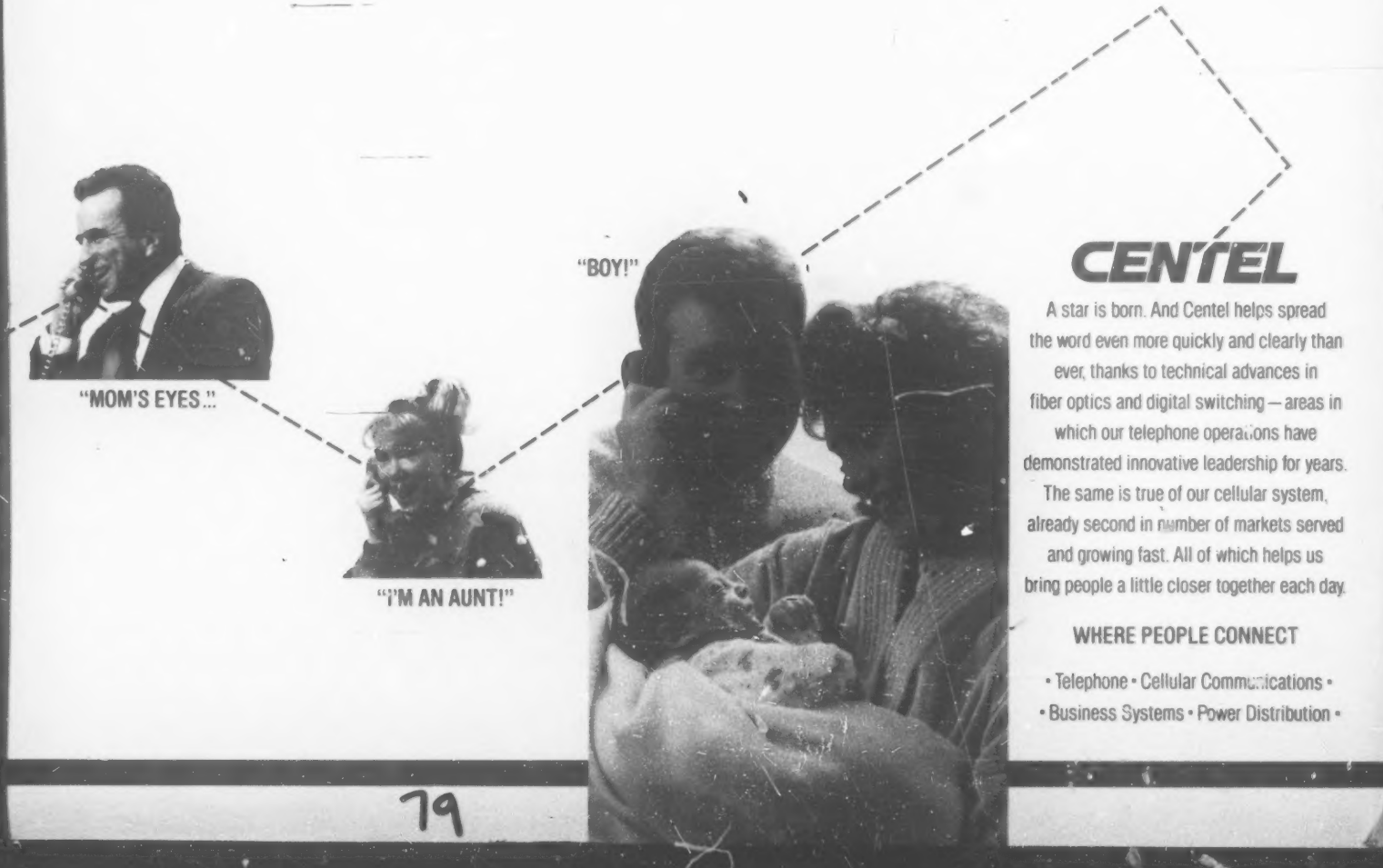
WILL FFV OWNERS avoid methanol if gasoline is cheaper? Oil executives grouse that it will cost 20 cents to 30 cents more for an amount that will do the work of a gallon of gasoline; they fear they may have to raise the price of gasoline to subsidize the price of methanol. Chemical companies that make methanol, and which have surplus capacity, say the price should be about the same as premium gasoline.

A limited switch to methanol, involving less than a tenth of the new cars sold annually, need not make the U.S. more dependent on imported fuel. Some in the Administration talk of using methanol made from natural gas in OPEC countries that now burn it off as waste, such as Saudi Arabia. But the U.S., Canada, and Mexico could supply all the natural gas needed for the President's clean air plan.

Methanol has its critics, not all in the oil business. Cars fueled with 100% methanol are hard to start at temperatures below 40° F. and require frequent oil changes. Though conventional pollutants would decrease, more of another would issue from the tailpipe—formaldehyde, an eye-stinging smog former that was used to pickle the frog you dissected in high school bio lab and that is now thought to cause cancer. Methanol itself is highly toxic. A jigger or so can kill or blind you. And if you have an accident in bright sunlight, you might get burned by failing to notice methanol's nearly invisible flame.

Automakers are working hard to overcome the problems. New lubricating oils, they hope, will stand up well. To add volume to the fuel tank, Detroit is experimenting with plastic polymers that can be molded to take advantage of every spare nook and cranny under the chassis. Firing up the car in cold weather is easy with a blend of 85% methanol and 15% gasoline, known as M85. It allows quick starts at

* *The nine, in order of intensity of ozone pollution: Los Angeles, Houston, New York City, Milwaukee, Baltimore, Philadelphia, Hartford-New Haven, San Diego, and Chicago.*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"I'M AN AUNT!"
"BOY!"
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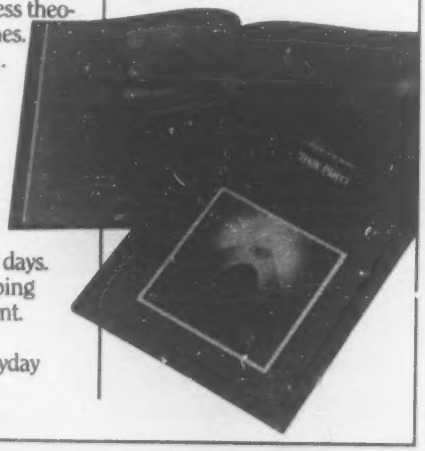

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temperatures down to −20° F. and burns with a bright yellow flame. Using M85 instead of pure methanol, however, has a price: The reduction in smog falls from 90% to 50%.

California has set strict standards for formaldehyde emissions, which automakers will control with redesigned catalytic converters. Converters installed on today's conventional cars can meet the standard when new, but fall short by the time the car has reached 50,000 miles.

Detroit is also taking steps to make sure drivers don't take a fatal swig of wood alcohol. Fuel most commonly enters the body when a motorist siphons it from a tank; an estimated 14,000 Americans a year swallow gasoline while sucking on a tube to get the siphoning process started. Automakers will install strainers in the mouth of the tank to prevent drivers from having the drink to end all drinks.

BIG OIL, its livelihood at stake, hopes to head off alternative fuels with revamped gasoline. In August, Arco announced a new lead-free gasoline for pre-1975 cars without catalytic converters. It cuts tailpipe emissions by 15%. For newer cars, oil companies might try to get rid of gasoline's more volatile components and add oxygen-rich chemicals made from methanol and ether that make fuel burn more fully and boost octane.

Top engineering officials from the oil and auto industries are holding a series of meetings to discuss new formulations and changes necessary in engines to help the redesigned fuels work better. Says Jim White, in charge of Arco's alternative-fuel project: "We think that methanol is a fuel of the future. We just don't think it's *the* fuel of the future. We'd rather have the chance to fool around with our gasoline."

The EPA doubts that cleaner gasoline could cut pollutants from newer cars by more than 15%. Even if the oil companies can make gasoline cleaner, at least one authority in Detroit thinks it's worth going the extra mile with methanol. "We certainly are supportive of the oil companies' efforts to make clean gasoline," says Ford's Roberta Nichols. "But we still see methanol as the replacement in the long term. And in the short term methanol would still have the advantage in air quality and higher power." The payoff in more breathable air alone seems well worth the expense. F

HOW TO BREAK THE SOFTWARE LOGJAM

Programming takes longer—and costs more—than most computer users expect. Don't count on a high-tech fix. Smarter management can unclog the bottlenecks. ■ *by Brenton R. Schlender*

SOFTWARE IS HARD. Just ask Jim Wile, senior business systems analyst at the Board of Water & Light in Lansing, Michigan. Since 1985 he has been working on what looked like a simple enough task: designing new computer software so the utility can combine charges for water and electricity service on a single monthly statement instead of mailing out separate bills for each. The original timetable called for the work to be done in two years. So far Wile and his programmers have spent more than 40 man-years and $2 million on the project. He suspects it will take half again that much work and another $1.5 million before the utility can finally start saving itself and its customers some postage stamps.

What appeared a straightforward technical task turned out to raise a broad range of management questions. "The whole project amounted to a philosophical change at the company, not just new software," says Wile. "It took many hours of debate, sorting through a ton of procedural issues, and it required policy decisions completely unrelated to the actual coding. And now we've spent nearly five years without any deliverable benefit."

Wile and his crew are victims of the software bottleneck that is squeezing just about every organization that relies on computers. Software is the taskmaster that tells computers what to do and how and when to do it. Without it, a computer might as well be a doorstop. But as computers grow more powerful and user demands grow more sophisticated, the process of developing new software and of maintaining and modifying old systems has turned into an exercise in frustration, in some cases at the cost of tens of millions of dollars and squandered business opportunities.

Wile's experience underscores what many companies are discovering: The software monster is easily as much a managerial problem as a technical one. Following half a dozen simple guidelines can help managers free programmers to work more effectively. For executives who need outside help, a whole industry has sprouted to provide services from project management advice to "body shops" of temporary programmers. If the mess looks truly hopeless, as a last resort there's even a Red Adair of software—so nicknamed after the famous douser of intractable oil well fires.

On the technical side, companies are inventing new programming languages and computerized tools that streamline the writing of software code. The federal government, which pays for a quarter of all programs, has chartered think tanks to study development methods and rate software contractors. And companies that use lots of software are setting up repositories of proven code that can be reused in new applications so that programmers don't have to start from scratch each time out.

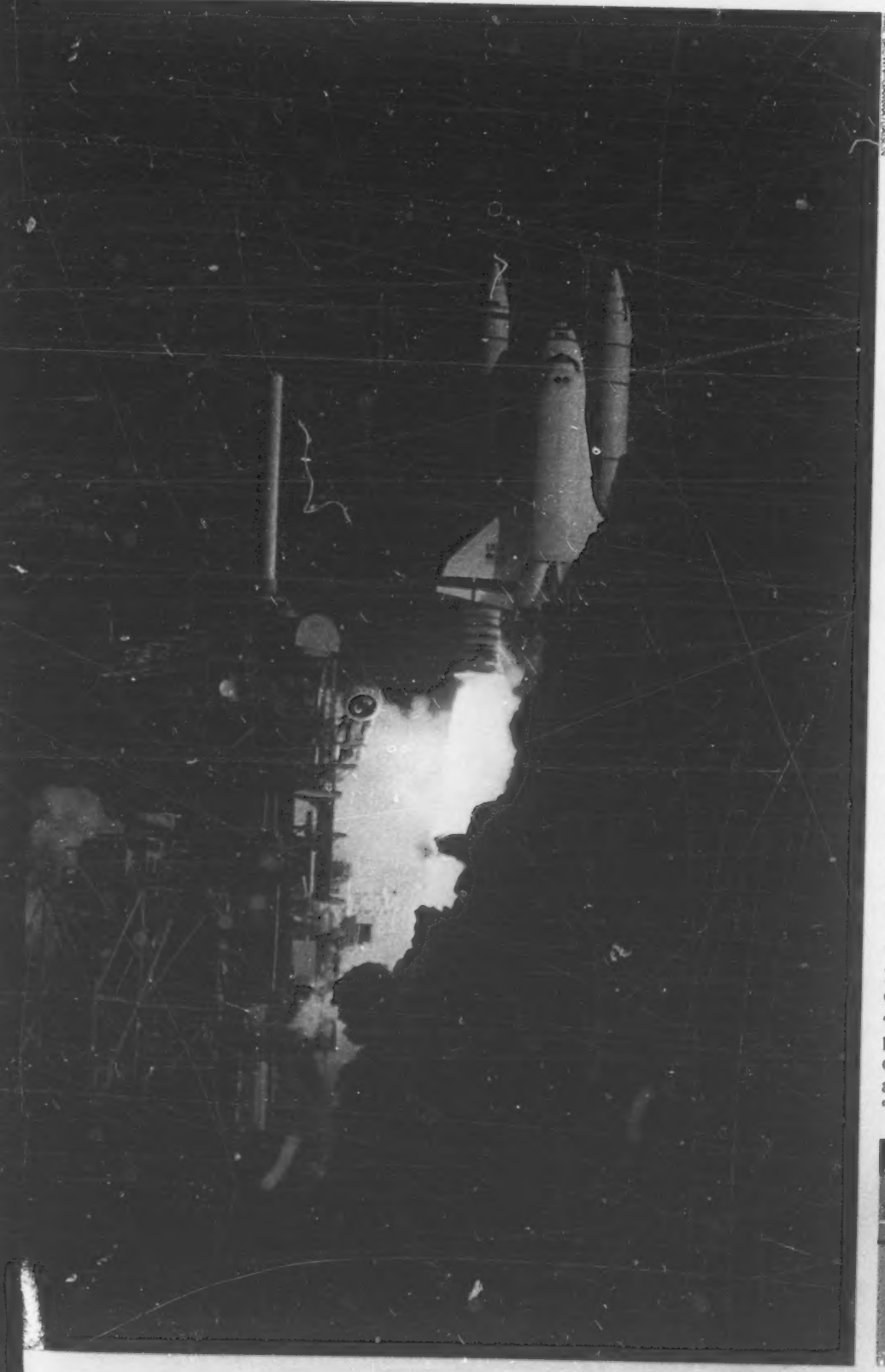
None of this comes any too soon. Software logjams contributed to the delayed debut of the awesomely complex B-2 Stealth bomber, and the sheer logistical horror of writing tens of millions of lines of code helped sidetrack Star Wars. Not even companies whose sole business is writing programs have escaped unscathed. Two of the most successful personal computer software makers—Lotus Development, creator of the 1-2-3 electronic spreadsheets, and Ashton-Tate, best known for d-Base—have suffered costly, embarrassing holdups getting the latest versions of their flagship products out the door.

BRIAN SMITH

LOTUS 1-2-3, VERSION 3

Lines of code	Labor required	Development cost	Cost of quality control testing
400,000	263 man-years	$7 million	$15 million

To get the bugs out, Lotus spent millions in this room testing the latest version of its popular 1-2-3 electronic spreadsheet on virtually every IBM-compatible machine.



MIKE BROWN-CAMMA/JACKSON

The stakes are vast. The U.S. will spend $112 billion this year on software. The Pentagon alone accounts for $30 billion—10% of the 1989 defense budget. Software is one of the biggest corporate capital outlays: Merrill Lynch shells out $160 million each year on software, while United Airlines' Covia subsidiary spends $120 million a year maintaining and updating software for its Apollo reservation system. The backlog of overdue and overbudget projects keeps growing. Says Capers Jones, chairman of Software Productivity Research Inc. in Cambridge, Massachusetts: "All over the world senior executives and government officials are wondering why software development is so expensive, why it takes so long, and whether there is any reasonable prospect for improving its economics."

WHY IS SOFTWARE such a tar pit? For decades software specialists have pinned the blame on the nature of the beast itself. As one expert puts it, software is "pure thought stuff," so conceptual that designers can't draw explicit, detailed diagrams and schematics—as creators of electronic circuits can—to guide programmers in their work. Consequently, routine communication among programmers, managers, and the ordinary people who use software is a chore in itself. "Making software is unlike any other business activity," says Michael Hammer, a corporate computing consultant also in Cambridge. "Imagine putting together an instruction manual on how to assemble a car for someone who had never even seen one. That's what you're doing when you write a program."

While the performance bang per buck's worth of computers doubles every three years or so, improvements in software productivity chug along at a far more modest 4% annual rate. Frank King, senior vice president of software products at Lotus, contends that building a new program takes a lot more work than designing a new chip. "The labor content in large systems like

SPACE SHUTTLE

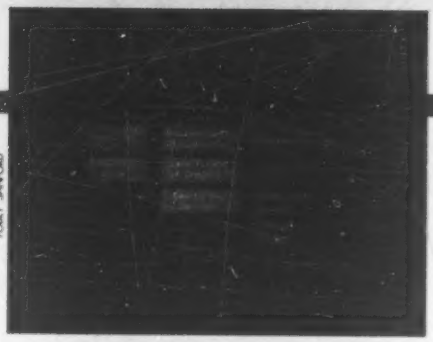
Lines of code	Labor required	Development cost
25,600,000	22,096 man-years	$1,200 million

Because lives are at stake, the space shuttle contains some of the largest, most sophisticated, and most expensive software programs yet developed. It took a cast of thousands to do the job.

those in the space shuttle is equivalent to what it took to build the Great Pyramid," asserts Jones, whose firm analyzes such statistics. "Big corporate systems take hundreds of people eight or ten years to build." To make matters worse, top-notch programmers and project managers remain in short supply.

The design of a program can take systems analysts months or even years, but it is the actual coding and testing that really burn up the man-hours. Programmers take a design that is described only in general terms and turn it into massive lists of thousands—sometimes even millions—of meticulously detailed commands, an extended string of decision trees that tell the computer exactly what to do in every circumstance.

To do this, programmers use personal computers or technical workstations to write, edit, organize, and test the discrete pieces of code so they not only function efficiently but also dovetail with the rest of the program. The trick is to make each piece as compact as possible, eliminating redundant commands and functions. The hard, often mind-numbing work requires absolute concentration. System designers frequently make the job even more frustrating by adding new functions late in the process, which forces programmers to go back and rejigger what they've done before.



TOBY SANFORD

CITIBANK TELLER MACHINE

Lines of code	Labor required	Development cost
730,000	150 man-years	$13.2 million

Citibank's automated touch-screen teller machines speak three languages and rely on nearly as many lines of software code as there are listings in the Manhattan telephone directory.

1989 LINCOLN CONTINENTAL

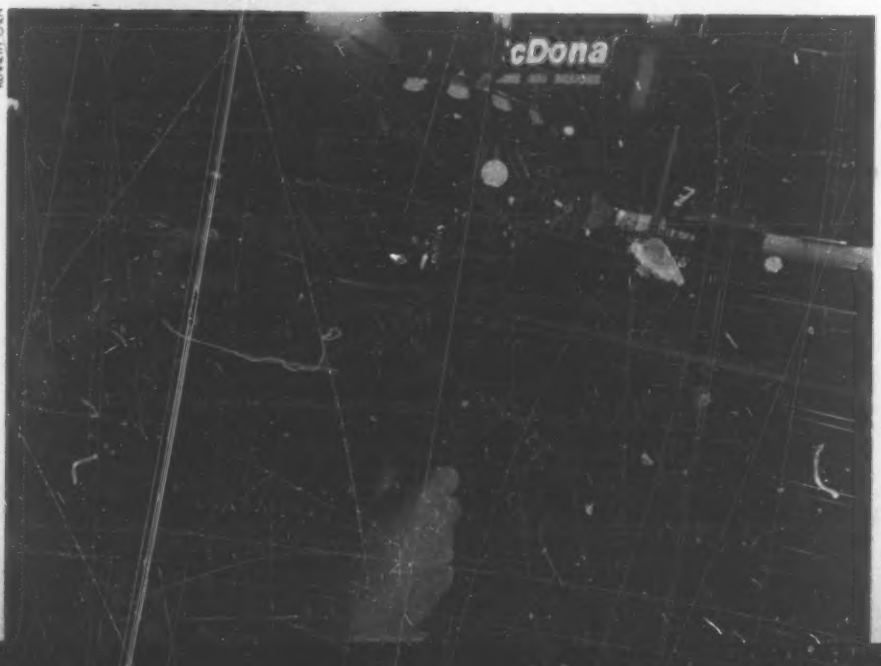
Lines of code	Labor required	Development cost
83,517	35 man-years	$1.8 million

Cars can't run without software these days. On this $29,000 luxury sedan, programs control the digital dashboard, brakes, air bag, door locks, steering, suspension, engine, and air conditioner.

The accompanying charts and photographs illustrate just how much labor and expense went into building the software that controls a variety of familiar computerized devices, from the space shuttle to a supermarket checkout scanner. In each case, Capers Jones's firm provided the estimates of cost and man-years of effort. All but Lotus 1-2-3 include quality control testing in the development cost.

For all the technical problems, the biggest obstacles to effective, economical software development are managerial. In case after case, the cause of delayed or botched software invariably boils down to bad planning, organizational rivalries, unrealistic scheduling, or the inability of techies to grasp the business problems they are trying to solve. "Software may be complex, but it isn't a black art," says Watts S. Humphrey, director of the software process program at the Software Engineering Institute at Carnegie Mellon University in Pittsburgh. "All those good management practices that apply to factories and engineering work for software too. But these are not things that technical people in the bowels of companies have been trained to do."

Humphrey's institute was founded in 1984 after the Pentagon declared itself mired in a software crisis. Since then he has studied how well hundreds of government software projects were run. His conclusions are sobering: Two-thirds had no formal procedure for estimating the amount of labor or code required, and nearly half had no standard way to predict the cost of a program. Small wonder that the Air Force complains of a four-year backlog or that other studies show that one in four military software projects is simply abandoned.



KENNETH OPEN

NOWADAYS computers and software are integral to just about every weapons system except a grunt's rifle. But unlike a spreadsheet or a word-processing program, military software must operate without flinching in the most harrowing conditions. Big weapons systems require more programming code than just about any other user of software. The B-2, for example, has 200 computers and tens of millions of lines of software instructions. "To visualize a million lines of code, think of this," says Humphrey, "the Manhattan white pages has about 868,000 listings."

Adds Geoffrey W. Turner, a former naval intelligence officer: "These systems are so big that no single person can truly understand them, so you have to wonder if they can be managed at all." Now a consultant for SRI International, a research institute in Menlo Park, California, Turner spent many of his 14 Navy years working on software that manages the U.S. strategic nuclear war plan. Says he: "Watching the process from the inside, I was alarmed that nobody had any real idea of what it was we were building or how it would work."

Happily, most corporations don't have to worry that software screw-ups might inadvertently ignite World War III. Their most vexing concern isn't building new programs at all, but maintaining and modifying old software. According to KPMG Peat Marwick's information technology group, this

REPORTER ASSOCIATE *Philip F. Newman*

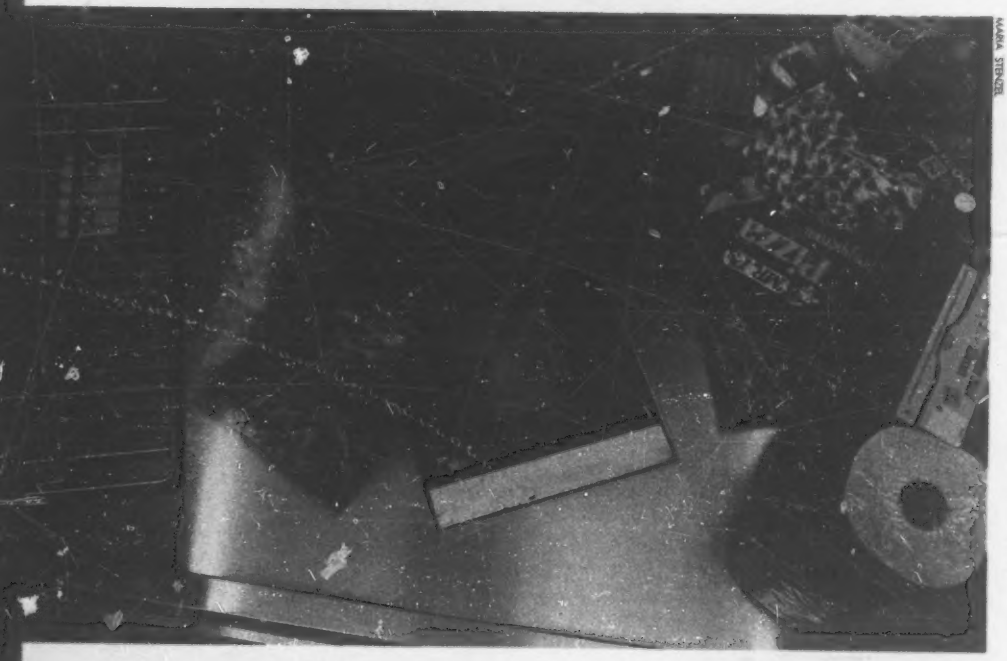
consumes about 80% of most corporate software budgets. "Much of the automation of major corporations was done in the 1960s and the 1970s," says DuWayne Peterson, a Merrill Lynch executive vice president in charge of technology. "These big, old systems are Frankenstein monsters, patched and redone." Modifying them, he says, "is like performing a heart transplant. The new heart isn't the problem, it's connecting it up so it won't get rejected."

With what little resources they have left, corporate software developers try to create new services for management. At a bank, that might mean designing a new type of account or loan. An airline might add car-rental booking to the reservation system. But often new software changes the way an enterprise does business. Sun Microsystems Inc. learned this lesson recently when a new system designed to direct salesmen's orders automatically to computer assembly lines disrupted manufacturing procedures. As a result, the highflying Mountain View, California, company, which hadn't posted a loss since 1982, abruptly fell into the red last quarter.

IBM CHECKOUT SCANNER

Lines of code	Labor required	Development cost
90,000	58 man-years	$3 million

The speedy software in IBM's beeping point-of-sale scanners shortens the checkout lines in supermarkets and helps improve accuracy. This one is at a Food Lion store in Hagerstown, Maryland.



MARK STEINZ

Computers are so powerful today that they can go beyond inventory control and other conventional processes to provide new strategic business advantages. That sounds inviting, especially to technologically adept CEOs who want to get more value out of expensive systems. But it can intimidate existing organizations, managers, and staffers who are loath to let a mere computer dictate changes in the way they do business.

When such sweeping, strategic systems go awry, the costs can be staggering. BankAmerica Corp. has been stung twice in recent years, at a cost of more than $100 million. The first snafu, in 1987, involved an innovative system for managing institutional trust accounts that was rushed into operation, only to snarl the records of some important customers. BankAmerica ultimately abandoned the system, which cost more than $20 million, and switched to another after reserving $60 million to cover potential losses. Then, late last year, a subcontractor the company had hired to process federally guaranteed student loans for a group of big banks had a computer failure when it tried to switch to a more advanced version of its software. That led to possible loan losses and administrative and legal costs as high as $650 million. The government refused to bail out the banks. The problem accounted for much of the $96 million BankAmerica set aside last winter to cover various potential losses.

More often software fiascos resemble what happened to Lansing's Board of Water & Light, where a seemingly simple effort to consolidate some accounting procedures spiraled out of control, taking more than twice as long and costing over twice as much as anticipated. KPMG Peat Marwick's technology services division calls these projects "runaways" and estimates that more than 30% of all companies fall victim to them.

It's James A. Willbern, a Dallas-based national director for KPMG Peat Marwick, who bills himself as the Red Adair of runaway computer systems. He and his team of 35 specialists usually arrive on the scene to rein in an errant project when all else has failed. The Lansing utility is one of his smaller clients. "I'm continually amazed at the size of some of these projects," he says. "We're looking at a project for a new switching system at one of the Bell companies that will run into hundreds of millions of dollars." This client took the precaution of consulting Willbern early, in hopes of preventing a runaway. Willbern's business is booming, as is the whole industry that provides software and management services to companies: Last year it took in $11.1 billion in revenues, according to International Data Corp., and it's growing 16% annually.

TO BRING ORDER to its product development division, Lotus hired Frank King last year from IBM, where he had been in charge of developing complex database software for mainframe computers. He found haphazard project management, but more nettlesome were a slew of problems unique to the PC software industry. PC software companies must make sure their products will work on thousands of different but supposedly compatible PCs and peripherals. Because these companies hope to sell their programs to millions of customers, no two of whom use them the same way, their products must be hardier than custom-designed programs for a single buyer. All told, Lotus spent $15 million testing a new version of its popular 1-2-3 spreadsheet, which reached the market over a year behind schedule. More than anything, says King, it's a question of managing quality control.

What is the hapless software consumer to do? Technical help is on the way in several forms, including CASE (computer-aid-

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ed software engineering) tools that use software to build new software, as well as innovative languages and techniques like object-oriented programming that make it easier to reuse blocks of code for basic word-processing. Besides technology, though, the experts say good old-fashioned management can go a long way toward easing the problem. Here are a handful of their specific suggestions:

■ **Give data-processing departments the same clout as everybody else.** "I'm a peer of the business guys, and that's the way it should be," says Merrill Lynch's Peterson. Putting corporate data-processing departments on an equal footing with other business units gives software projects the imprimatur of top management. This is especially important when new software will force changes in business procedures.

■ **Keep both managers and ultimate users involved in every step of software development.** "It can't be a we-they approach, it's got to be *us*," says Max Hopper, senior vice president for information systems for American Airlines. He runs Sabre, the world's largest computerized airline reservation system. Hopper adds, "Too often the high priests in the centralized data-processing departments try to come up with new systems without including the business people in the process."

■ **Make data-processing managers periodically work side by side with software users.** "You have to get outside," says Ann Beadle, second vice president for group pensions and information systems at Unum Corp., a Portland, Maine, insurance company. She recently helped install—on time and within budget—a complex software system to manage employee pension plan investments for Unum's customers. Her previous stint managing the 401(k) pension plan for Unum's own employees gave her an insider's feel for the problem.

■ **Break up big projects to keep programming teams small.** "That's what I would do next time," says Wile, the Michigan utility software analyst. The optimum size for a team is five to ten members, mainly because management and communication get cumbersome in larger groups. Besides, it is easier to measure progress in a smaller project. "You have to remember that software people are very goal oriented and like to see results," Wile says.

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James Willbern: the Red Adair of software

■ **Give programmers elbowroom.** One of Capers Jones's productivity studies shows that a programmer or analyst who has 100 square feet of office space is twice as productive as one squeezed into 40 square feet. Programmers packed into tight quarters are easily distracted, and they need lots of room to spread out reference materials. IBM kept this in mind when it built its massive Santa Teresa Laboratory in San Jose, California, where it conducts much of its software work. The rambling structure, unofficially dubbed the Martian Embassy, gives programmers plenty of room, bucolic outdoor lounges, and lots of natural light.

■ **Make existing software easier to maintain.** Companies should transform dated code into fresher versions more attuned to today's computers. A whole industry, which Jones calls "geriatric care for aging software," now provides services that make this easier. The process is expensive but usually worthwhile.

Ultimately, executives have to recognize that they can't count on a technological silver bullet to slay the software dragon. Despite the promise of new tools and innovative programming techniques and management, software remains the most complex and abstract activity man has yet contrived. Getting the job done will always come down to patience, ingenuity, and lots of elbow grease. ■